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14. ABSTRACT

Our Summer 2000 preliminary study of HF-PMSE is in review at GRL and the 2001 campaign is in full swing. We will have a full climatological study at HIPAS and a long campaign at HAARP. The latter will include 139 MHz studies as well.

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APPLICATION OF AND ENHANCEMENT TO ARCTIC INFRASTRUCTURE FOR THE STUDY OF LONG-TERM CHANGE IN THE EARTH'S POLAR MESOSPEHRE

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I. Statement of Effort

Our Summer 2000 preliminary study of HF-PMSE is in review at GRL and the 2001 campaign is in full swing. We will have a full climatological study at HIPAS and a long campaign at HAARP. The latter will include 139 MHz studies as well.

II. Accomplishments/New Findings

Abstract

We present initial Polar Mesosphere Summer Echoes (PMSE) observations using the HIPAS observatory at 4.53 MHz. Echoes were detected slightly above 87 km in almost all of our observations. The signal-to-noise ratio sometimes exceeded 15 dB. We also present the effects that ionospheric heating and different transmitted power made on PMSE strength. We do not detect evidence that electron heating occurred. This is the beginning of an effort to create a climatological observation of PMSE at HF, which will give us insight of PMSE as a possible indicator of global change.

Introduction

Polar mesosphere summer echoes (PMSE) have been studied intensely ever since their discovery by *Ecklund and Balsley* [1981]. Although there is an important relationship between the cold temperature of the summer polar mesosphere, the presence of electrons and charged aerosols, and PMSE generation, the underlying processes governing PMSE occurrence are still not clearly understood [e.g., *Cho and Morley*, 1995; *Balsley and Huaman*, 1997]. Present theories, however, all involve the existence of charged ice aerosols. Our current understanding of PMSE is discussed by *Hoppe et al.* [1994], *Cho and Kelley* [1993], and *Balsley and Huaman* [1997].

In general, PMSE appear as a narrow band of intense echoes at VHF near the summer mesopause above the 65° latitude [e.g., *Cho and Kelley* 1993]. PMSE are also seen at higher radar frequencies, such as 933 MHz [*Röttger et al.*, 1990] and 1.29 GHz [*Cho et*

al., 1992]. The Bragg scale of the radar wave scattering is below the scales commonly associated with inertial range turbulence in the upper mesosphere. PMSE have also been recently observed at high frequencies at the SURA heating facility [*Karashtin et al.*, 1997] and the HF Active Auroral Research Program (HAARP) observatory [*Kelley et al.*, 2001].

We are interested in PMSE occurrence coincident with noctilucent clouds (NCL) as well as the detectability of PMSE at high frequencies. Here we present the initial results of PMSE observations at the High Power Auroral Stimulation (HIPAS) Observatory. This is not only an additional proof of concept that PMSE can be detected at high frequencies and are similar to the VHF/UHF measurements of PMSE, as the HIPAS observations are also the beginning of a long-term (i.e., over many successive years) climatological observation of PMSE. We believe that a long-term observation of PMSE will provide insight into the relationship between the occurrence of PMSE and the variation of mesopause temperature at high latitudes. In addition, this radar data set will allow us to examine the coincident appearance of PMSE with NCL.

The discussion is organized as follows. We first discuss the experimental setup. The initial observations are presented. In our experiment, we exploited the flexibility of the HIPAS system and examined the relationship between PMSE return and transmitted power as well as ionospheric heating. The initial interpretations are then presented.

Experiment

HIPAS consists of 8 cross-polarized dipoles operating in the frequency range of 2.85 MHz to 4.911 MHz, with maximum transmitted power of about 800 kW. HIPAS has been used in many experiments involving high-power wave interactions at auroral latitudes [e.g., *Wong et al.*, 1990]. In addition, the HIPAS heater facility is used for ionospheric modification experiments by transmitting powerful radio waves in the HF band [e.g., *Djuth et al.*, 1997].

As there is evidence that PMSE returns are detectable at high frequencies, starting on June 8, 2001 the HIPAS HF observatory near Fairbanks, Alaska was operated in pulsed mode to begin a long-term observation of PMSE. This is our main focus. In this experiment, we operated the HIPAS HF heater from 10am to 2pm at O-mode at 4.53 MHz. We configured the heater to operate in pulsed mode transmitting 15 μs-pulses with an inter-pulse period for 15 ms at ~400 kW. The range resolution is 2.25 km. A delta-loop antenna acted as the receiving antenna. Timing between the receiver and the transmitter is accomplished with a synchronized pulse. 64 data points were stored as a single data record and written to disk. This procedure results in a dwell time of ~1 second.

There is also evidence that ionospheric stimulation would effect an observable modification of PMSE [*Chilson et al.*, 2000]. We investigate this phenomenon by first operating HIPAS in CW-mode operating at 4.53 MHz and transmitting ~400 kW. We will describe the heater operation as needed in the Data Presentation section.

Data Presentation

The climatological observations started on June 8 and PMSE was detected. In Figure 1 we present the signal-to-noise ratio. The white gaps indicate periods where either the

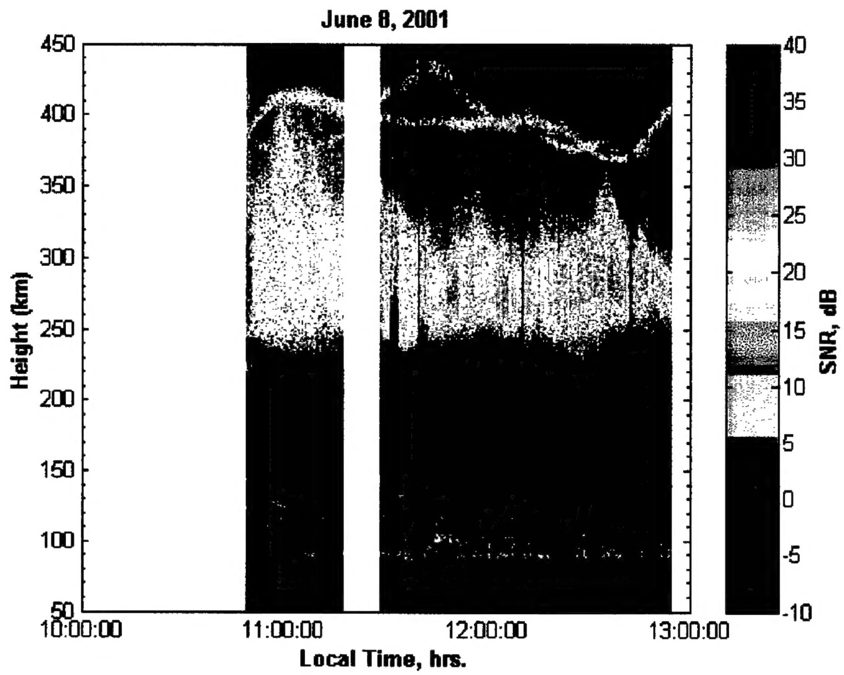

Figure 1.

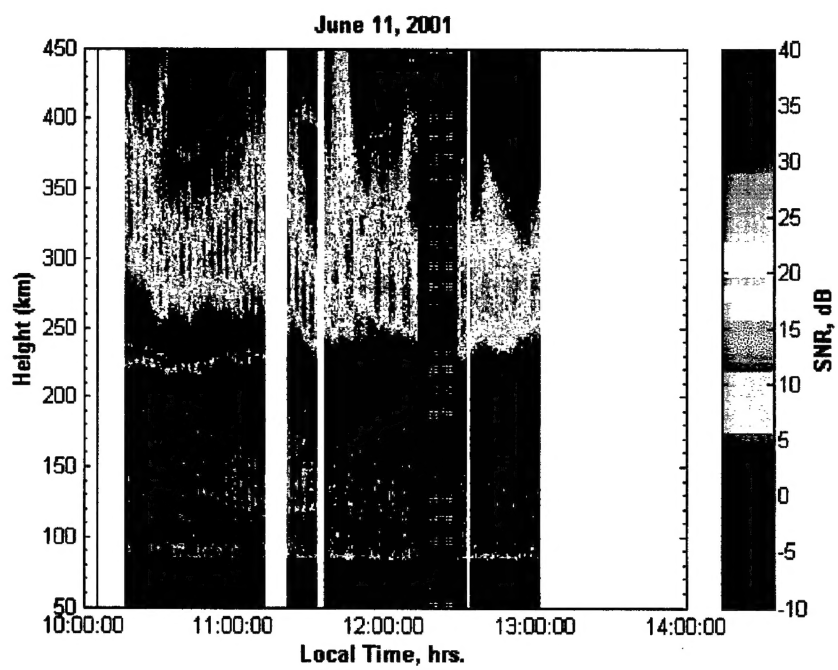

Figure 2.

heater was not turned on or data was not acquired. PMSE were detected throughout this ~2 hour observation. The most common echoes occur in 85 km < z < 90 km. There was some variability in the PMSE return, with the strongest return occurring near noon.

Figure 2 presents the SNR collected on June 11. The data gap between 12:23 and 12:28 pm indicates the period where the heater was switched from pulsed mode to heater mode and the heater transmitted 400 kW at CW for 5 minutes. We suspect that striations revealed in the RTI plot were the result of interference from local short-wave sources. Although it might have been possible to lower the bandwidth of the receiver to get a cleaner signal, we chose not to do so, as geophysical signal might have been inadvertently filtered out. In this observation, PMSE was again observed with some variability since the PMSE return intensified as we approached noon. The effect of ionospheric heating on PMSE return will be analyzed in the near future.

Conclusion

In this paper, we present our initial PMSE observations at the HIPAS Observatory. PMSE are seen for 85-90 km, which is comparable to previous PMSE observations at VHF and UHF [e.g., *Ecklund and Balsley*, 1981; *Cho et al.*, 1992]. These observations encourage us to take advantage of the HIPAS Observatory by focusing its resources on aeronomic studies in the polar summer mesosphere. Of most interest for us are the frequency-agile log-periodic antenna and the Rayleigh lidar capable of Mie scatter from mesospheric cloud particles. These tools, used in conjunction with the heater, will allow simultaneous remote sensing of polar mesospheric clouds from scales of 100 m.

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III. Personnel Supported

Charles Chen, graduate student: summer
Editor I – 4% CY
Michael C. Kelley, P.I.: summer, salary recovery
Camilo Ramos, graduate student: summer

IV. New Publications

Kelley, M. C., M. Huaman, C. Y. Chen, and C. Ramos, HF PMSE observations at the HAARP Gakona ionospheric observatory, *Geophys. Res. Lett.*, submitted, 2001.

V. Interactions/Transitions

10th International Symposium on Equatorial Aeronomy (ISEA), Antalya, Turkey
Fall AGU Meeting
14th National Congress of the Australian Institute of Physics, Adelaide, Australia
Spring AGU Meeting
RF Ionospheric Interactions Workshop, Santa Fe, NM
CEDAR Workshop, Boulder, CO

VI. New Discoveries

None.

VII. Honors/Awards

Member, American Geophysical Union
Fellow, American Geophysical Union
Senior Member, IEEE
Weiss Presidential Fellow for Excellence in Teaching
James A. Friend Family Distinguished Professor of Engineering